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A DIGITAL ULSI INSPECTION METHOD USING PARALLEL SCANNING CONFOCAL MICROSCOPE

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Abstract

In ULSI fabrication, the design rule scaled up to 0.25um and the complex multiple layer structure prevent from applying the traditional optical microscope of which resolution is about 0.4um. Considering the situation, we have developed a ULSI inspection system based on the scanning parallel confocal microscope.

In this paper, we present the feature of the computer aided parallel scanning confocal ULSI inspection system.

First, we describe the principle of the scanning parallel confocal microscope with the stress on two key points of the semiconductor observation. One is the high resolution capability. We show an image of the resolution test with 0.2um line and space pattern drafted by Electron Beam Lithography to confirm the capability for the ULSI inspection. The other point is optical sectioning imaging. The imaging is very important to examine the ULSI surface of the multiple layer and high aspect ratio without the defocused energy of another area.

Considering the optical sectioning capability, we compare the parallel scanning confocal images of the ULSI device with the traditional microscope image in the digital inspection of the high aspect ratio's surface of multiple layer. We submit an interested layer in the digital confocal microscope image. Finally, we summarize the performance of the proposed system as the ULSI inspection.

1. Introduction

The advanced ULSI device such as 64MDRAM or RISC has the more complex multiple layer structure, scaling up the design rule to achieve the high speed calculation in EWS.

In the conventional inspection in the product process, the optical microscope has been used in the geometry process inspection station, its resolution (the actual limit is 0.4um.) is not suitable for such advanced device. In the high magnification such as 100 magnification over, the problem of the focus depth comes out. Although SEM Has the high magnification, SEM's EB damage is a serious issue for the manufacturing yield.

The other issue of SEM is the vacuum environment. It is an obstacle for the raw processed material. Considering such situation concerning inspection microscope, the scanning parallel confocal microscope has been investigated[1]. Damage-free in the normal atmosphere is the one of the biggest advantage of the optical microscope.

In this paper, we refer the feature of parallel scanning confocal optics and a prototype of the computer aided confocal system as the ULSI inspection station.

First, we present the principle of the scanning parallel confocal microscope in two key points of the semiconductor observation. One is the high resolution capability. We show as image of resolution test using 0.2um line and space pattern drafted by Electron Beam lithography System to confirm the effectiveness as the ULSI inspection station. The other point is an optical sectioning imaging. Imaging is very important to check an ULSI surface of the multiple layer and high aspect ratio without the defocused energy of the another area. Considering the optical sectioning capability, we compare digital confocal images of the ULSI with digital traditional microscope image in the multiple layer surface of the typical ULSI. Processing digital confocal images, we present a 436nm wave-length element image of one layer. Finally we summarize our system performance as the advanced ULSI inspection station.

2. Basic Principle of Scanning Parallel Confocal Microscope

The point of the confocal optics is to block out the reflected lighing energy through the objective lens which would tend to obscure the image[2]. The confocal optics has the capability to capture more clear image than the traditional optics by that point.

Using the lighting of more short wave length, we can get the more improved resolution result image compared with the visible lighting condition (620nm-480nm) as the equation(1)

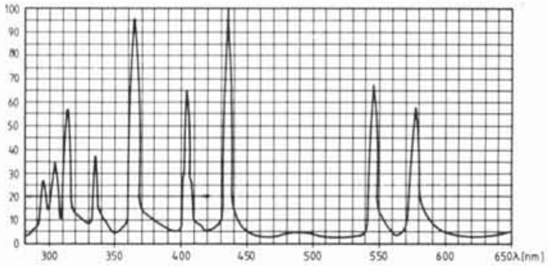

Fig.1 Relative Spectral Radiation of Mercury Lamp
We use 365nm,403nm, and 436nm wave length lighting in the Spectrum.

$$R = K \frac{\lambda}{NA} \qquad (1)$$

where R is resolution, K is optical constant. NA is numerical aparture, and λ is wave length.
In our system, K is 0.45, NA is 0.95, and λ is 0.436 (436nm) of the mercury burned lighting as Fig.1[3], then R is calculated to 0.2um.

We may consider that such confocal condition is optimized at the focus point at the surface of the device for the each lighting ray. Then, many laser confocal microscope has the serial scanning stage with the line senser which gets the confocal scanned images and reconstructs the results image. Our sytem uses the parallel scanning mode which can get the prural confocal microscope results image at once time. The benefits are to keep the inspecting accuracy by the area senser, and to utilize the most suitable lighting sources for the target device. In this paper, we apply the 436nm wave length of the mercury burned lighting.

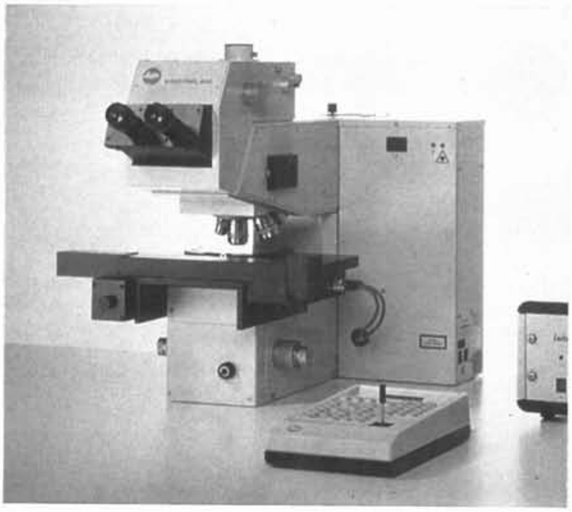

Fig.2 Overview of ERGOPLAN
Base Microscope of the Proposed System

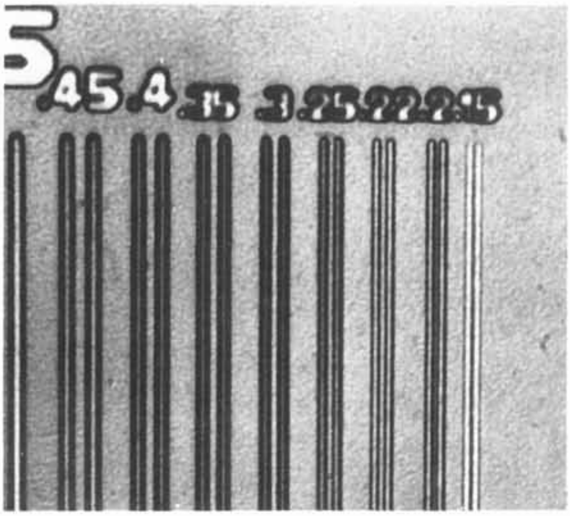

Fig.3 Result Image of Parallel Scanning Confocal Microscope
Recognized Line and Spase on 0.2um pitch

3. Experiment System Overview

In the proto-type system of the inspection station, we use ERGOPLAN in Fig.2 which has the capability of 0.3um resolution, and its optical constant is 0.45, as the platform of the system.
The digital image is captured by TI MC-1000WMS CCD camera which has developed as the 436nm wave length lighting imaging senser and the image size is 1000*1017 pixels, or PhotoCD through photograph. The digital image processing is operated in AVS Ver.5.0 of Sun SPARC station 10ZX. The images shown in this paper are displayed on the moniter of the EWS.

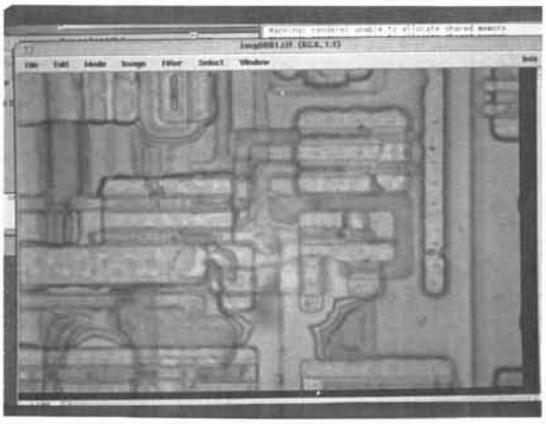

Fig.4 Result Imge of Traditional Microscope

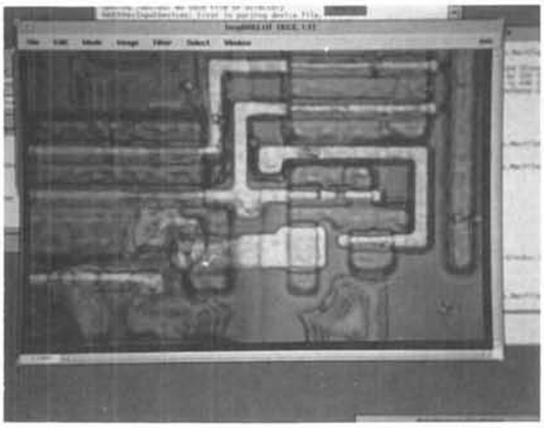

Fig.5 Result Image of Parallel Scanning Confocal Microscope
The bright area is located in the focus position.

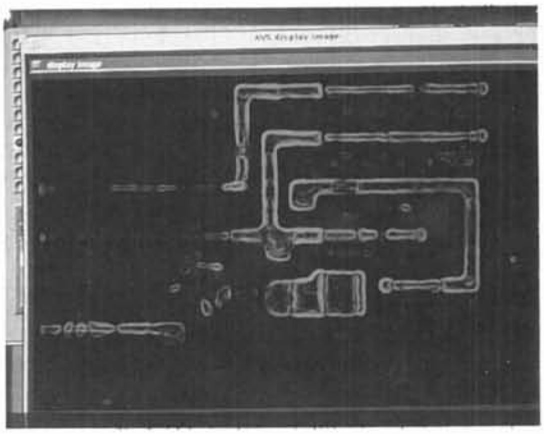

Fig.6 Detected Layer in Parallel Scanning Confocal Microscope Image

4. Application to ULSI Inspection

4-1 High Resolution Observation

In the inspection for 0.35um design rule device, the resolution of the traditional microscope is insufficency, which is 0.5um. Fig.3 indicates the confocal microscope result image of the line and space chart. Clearly, the line and space pattern of 0.2um width is recognized in it.

4-2 Optical Slicing Imaging

In observing the structure of high aspect ratio, the focus-depth effect is typical issue. Fig.4 is the traditional microscope digital image of a device with three layers structure. A blured area around the metal gate is recognized in Fig.4. The blur energy decreases the resolution of the result image also. Although it is critical to justify the defect generating position and timing
in the process, it is troublesome operation to defind the attribute of the defect in the traditional microscope image.
Fig.5 shows the confocal microscope image which is focused at the top gate-metal layer(the brightest are). The feature of the confocal optics is the little focus depth. For the characteristic point, the focused area is gotten as the clear result image. On the other hand, the defocused area is not clear and dark as shown in Fig.5. Utilizing the confocal image, it makes sure to ease to identify the origine of the defect from the image.
Fig.6 shows the top layer metal area of the device, after the digital image processing which detect the most bright area as the focus position. As perceived , the cross section contour of the metal is seemed to be shaped as tapered.

5. Conclusion

As the number of the inspected points on ULSI is immense and the EB damage of SEM comes out, the development of the computer aided inspection system which is damage-free and high performance is very serious issue for the ULSI manufacturer. Moreover, the history of the process resluts images is critical for the engineering analysis. We propose the scanning parallel microscope digital inspection system for ULSI device with high aspect ratio structure of the multiple layers, and show the detected layer from the confocal microscope image to analyze the processed surface of ULSI.

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